REMARKS

This is intended as a full and complete response to the Final Office Action dated November 21, 2007, having a shortened statutory period for response set to expire on February 21, 2008. Please reconsider the claims pending in the application for reasons discussed below.

CLAIM REJECTIONS

35 U.S.C. §103(a) Claims 8-9 and 37-44

Claims 8-9 and 37-44 stand rejected as being unpatentable over *Miura* (U.S. Patent Publication No. 2003/0155247) in view of *Dubin* (U.S. Patent No. 6432821) and further in view of *Wang* (U.S. Patent No. 6528412). In response, the Applicants have amended claim 8 to more clearly recite certain aspects of the invention.

Independent claim 8 recites elements not taught or suggested by the combination of *Miura, Dubin* and *Wang*. As discussed in the previous response filed on October 29, 2007, *Miura* teaches using a conductive seed layer disposed on a substrate prior to a copper electroplating deposition process to provide enough required electric current to enable the copper electroplating deposition process. *See* Paragraph 13, Lines 6-9 and paragraph 14, lines 7-9. The conductive seed layer is formed by PVD or CVD. *See* Paragraph 50, Lines 3-6. *Miura* does not teach or suggest directly depositing a copper seed layer on a barrier layer, wherein the copper seed layer is formed across the entire barrier layer surface, annealing the copper seed layer and depositing a copper gap-fill layer on the copper seed layer, as recited by claim 8.

As evidenced by the declaration under 37 C.F.R. § 1.132 of Aron Rosenfeld filed with the response filed October 29, 2007, Mr. Rosenfeld has indicated that *Miura's* teaching of seed layer preservation process cannot be interpreted as a process for direct depositing a seed layer on a barrier layer. Additionally, *Miura* does not teach or suggest directly depositing a copper seed layer on a barrier layer, wherein the copper seed layer is formed across the entire barrier layer surface, annealing the copper seed layer and depositing a copper gap-fill layer on the copper seed layer, as recited by claim 8.

Dubin teaches using multiple steps to electroplating copper on a seed layer. Neither *Dubin* nor *Miura*, alone or in combination, teaches or suggests directly depositing a copper seed layer on a barrier layer, wherein the copper seed layer is formed across the entire barrier layer surface, annealing the copper seed layer and depositing a copper gap-fill layer on the copper seed layer, as claimed.

Wang teaches CVD or ALD depositing an adhesion skin layer on a barrier layer on a substrate. Subsequently, an electroplating process, *e.g.,* a wet process, may be performed to deposit a seed layer on the adhesion skin layer. A copper bulk fill process may be performed to fill in the bulk copper in the trench after the copper seed layer. An annealing process is performed after the copper seed layer process, but prior to a copper bulk filling process, to promote the adhesion between the copper seed layer and the adhesion skin layer. However, *Wang* does not teach or suggest (1) directly electroplating a copper seed layer on a barrier layer, (2) the electroplated copper seed layer is formed across the entire barrier layer surface, and (3) annealing the copper seed layer prior to a copper gap-fill layer.

The Applicants submit that seed layer as taught by *Wang* is deposited on an adhesion skin layer particularly chosen to match the seed layer for promoting adhesion between the layers. The annealing process is performed to specifically promote the adhesion between the adhesion skin layer and the copper seed layer. Furthermore, right after the annealing process, the bulk copper layer is deposited on the copper seed layer to form the interconnection. However, *Wang* does not teach or suggest directly electroplating a copper seed layer across an entire barrier layer surface. *Wang* does not teach or suggest annealing an electroplating a copper seed layer directly deposited on a barrier layer prior to depositing a gap-fill copper process. Furthermore, *Wang* does not teach or suggest depositing a copper bulk-fill layer on to the copper gap-fill layer by a third copper solution, as further recited by claim 9.

Specifically, the Examiner attention is directed to paragraph 39, lines 2-4 of the specification of the present application, it states that the annealing process is "....to obtain a better crystal orientation. Better crystal orientations improve electromigration resistance of the subsequent copper migration....." Accordingly, an annealing step after an electroplating copper seed layer on a barrier layer but prior to a copper gap

filled process followed by a copper bulk-fill process is specifically arranged to achieve specific result. By performing the annealing step at a specific order among these three step copper interconnection forming process, a reliable and repeatable process is obtained to achieve good crystal orientations that improves electromigration resistance for the electronic devices. *Wang* does not teach or suggest annealing an electroplating a copper seed layer directly deposited on a barrier layer prior to depositing a gap-fill copper process, as claimed.

Furthermore, the Examiner admits that the teaching of *Wang* would have suggested that the seed layer may be discontinuous and may not form at the sidewalls and bottom corners of the interconnect opening. Accordingly, *Wang* does not teach or suggest directly electroplating a copper seed layer across an entire barrier layer surface. Additionally, the Applicants respectfully submit that as noted by Mr. Rosenfeld in item 6 of the declaration, as indicated in the response filed on October 29, 2007, *Wang's* teachings cannot be interpreted as a process for directly electroplating a seed layer on a barrier layer. The Applicants respectfully submit that a conventional formed copper seed layer, formed by a CVD or PVD process, is typically required to provide a conductive surface on the substrate. As long as a conductive layer, *e.g.* a surface having sufficient conductivity, is formed on the substrate, an electroplating process would then be enabled. As well known in the art, an electroplating process is enabled by exchanging electrons provided from a conductive surface and copper ions, *e.g.*, Cu^{2+} or Cu, from the electroplating solution. The electroplating solution dissolves the conductive surface on the substrate, releasing some electrons to the solution. The copper ions from the electroplating solution receive released electrons from the conductive surface and reduce copper ions as copper atoms and precipitate copper atoms on the conductive surface, thereby forming the desired copper layer on the substrate. An insulating surface, such as a barrier layer surface, would not be able to provide electrons required to reduce copper ions from the chemical solution as copper atoms for depositing on the substrate. This is the reason why it is well believed that an electroplating process needs to be carried out on a conductive surface in order to enable the electron exchange process. As such, even though the seed layer of *Wang* may be discontinuous and may not form at the sidewalls and bottom corners of the interconnect opening, as admitted

by the Examiner, as long as there is at least some of the conductive elements exposed on the substrate, an electroplating process can be carried out using electrons from the exposed conductive elements, but deposition will occur on the conductive surface of the elements and bridge the non-conductive neighboring regions. Accordingly, *Wang* never teaches or suggests directly electroplating a copper seed layer on a barrier layer. Moreover, *Wang* never teaches or suggests directly electroplating a copper seed layer across an entire barrier layer surface. *Wang* does not teach or suggest annealing an electroplating a copper seed layer directly deposited on a barrier layer, wherein the copper seed layer is formed across the entire barrier layer surface, prior to depositing a gap-fill copper process, as recited by claim 8.

Therefore, combining the teaching of *Wang* into the teaching of *Miura* and *Dubin* would not yield annealing an electroplating a copper seed layer directly deposited on a barrier layer prior to depositing a gap-fill copper process, as claimed. Accordingly, the Applicants respectfully submit that the combination of *Miura* in view of *Dubin* and further in view of *Wang* would not yield directly electroplating a copper seed layer on a barrier layer, wherein the copper seed layer is formed across the entire barrier layer surface, annealing the copper seed layer disposed on the substrate, and depositing a copper gap-fill layer.

Thus, the Applicants submit that independent claim 8, and all claims depending therefrom, are patentable over *Miura* in view of *Dubin* and further in view of *Wang*. Accordingly, the Applicants respectfully request the rejection be withdrawn.

35 U.S.C. §103(a) Claim 10

Claim 10 stands rejected as being unpatentable over *Miura* in view of *Dubin*, and further in view of *Wang* and *Nagai* (U.S. Patent No. 6709563). In response, the Applicants have amended claim 8 to more clearly recite certain aspect of the invention.

Independent claim 8 recites elements not taught or suggested by the combination of *Miura*, *Dubin, Wang* and *Nagai*. The patentability of claim 8 over *Miura*, *Dubin,* and *Wang* has been discussed above. *Nagai* teaches a plating liquid containing divalent copper ions, a completing agent and an optional pH adjusting agent. However, there is no teaching or suggestion from *Nagai* that would suggest to one of ordinary skill

in the art to modify *Miura*, *Dubin,* and *Wang* in a manner that would yield directly electroplating a copper seed layer on a barrier layer, wherein the copper seed layer is formed across the entire barrier layer surface, annealing the copper seed layer disposed on the substrate, and depositing a copper gap-fill layer, as recited by claim 8.

Thus, the Applicants submit that claim 10, that depends from claim 8, is patentable over *Miura* in view of *Dubin* and further in view of *Wang* and further in view of *Nagai*. Accordingly, the Applicants respectfully request the rejection be withdrawn.

35 U.S.C. §103(a) Claims 20-21 and 45-52

Claims 20-21 and 45-52 stand rejected as being unpatentable over *Miura* in view of *Dubin*, and further in view of *Wang*. In response, the Applicants have amended claim 20 to more clearly recite certain aspects of the invention.

As discussed, the combination of *Miura*, *Dubin* and *Wang* does not teach or suggest directly electroplating a copper seed layer on a barrier layer and annealing the copper seed layer in an oxygen free environment disposed on the substrate, and depositing a copper gap-fill layer, as recited by independent claim 20. Specifically, *Wang* is silent regarding what kind of process environment that the annealing process may be performed. Accordingly, the combination of *Miura*, *Dubin* and *Wang* does not teach or suggest annealing a copper seed layer directly electroplated on a barrier layer in an oxygen free environment. As such, a *prima facie* case of obviousness has not been established as the references fail to teach each claimed elements.

Thus, the Applicants submit that claim 20, and claims 21 and 45-52 depending therefrom, are patentable over *Miura* in view of *Dubin* and further in view of *Wang*. Accordingly, the Applicants respectfully request the rejection be withdrawn.

35 U.S.C. §103(a) Claim 22

Claim 22 stands rejected as being unpatentable over *Miura* in view of *Dubin* and further in view of *Wang* and *Nagai*. In response, the Applicants have amended claim 20 to more clearly recite certain aspects of the invention.

As discussed, the combination of *Miura*, *Dubin* and *Wang* and *Nagai* does not teach or suggest directly electroplating a copper seed layer on a barrier layer and

annealing the copper seed layer in an oxygen free environment disposed on the substrate, and depositing a copper gap-fill layer, as recited by independent claim 20, from which claim 22 depends from. As such, a *prima facie* case of obviousness has not been established as the references fail to teach each claimed elements.

Thus, the Applicants submit that claim 22, that depends from claim 20, is patentable over *Miura* in view of *Dubin* and further in view of *Wang* and in view of *Nagai*. Accordingly, the Applicants respectfully request the rejection be withdrawn.

35 U.S.C. §103(a) Claims 31-32 and 53-58

Claims 31-32 and 53-58 stand rejected as being unpatentable over *Miura* in view of *Dubin* and further in view of *Wang*. In response, the Applicants have amended claim 31 to more clearly recite certain aspects of the invention.

As discussed, the combination of *Miura*, *Dubin* and *Wang* does not teach or suggest directly electroplating a copper seed layer onto a barrier surface, wherein the copper seed layer is directly formed on the barrier surface without intervening layer disposed therebetween, as recited by independent claim 31. As such, a *prima facie* case of obviousness has not been established as the references fail to teach each claimed elements.

Thus, the Applicants submit that independent claim 31, and claims 32 and 53-58 depending therefrom, are patentable over *Miura* in view of *Dubin* and further in view of *Wang*. Accordingly, the Applicants respectfully request the rejection be withdrawn.

35 U.S.C. §103(a) Claim 33

Claim 33 stands rejected as being unpatentable over *Miura* in view of *Dubin* and further in view of *Wang* and *Nagai*. In response, the Applicants have amended claim 33 to more clearly recite certain aspects of the invention.

As discussed, the combination of *Miura*, *Dubin* and *Wang* does not teach or suggest directly electroplating a copper seed layer onto a barrier surface, wherein the copper seed layer is directly formed on the barrier surface without intervening layer disposed therebetween, as recited by independent claim 31, from which claim 33 depends. As discussed above, *Nagai* does not bridge the deficiencies of the

combination of *Miura*, *Dubin* and *Wang*. As such, a *prima facie* case of obviousness has not been established as the references fail to teach each claimed elements.

Thus, the Applicants submit that claim 33, that depends from claim 31, is patentable over *Miura* in view of *Dubin* and further in view of *Wang* and in view of *Nagai*. Accordingly, the Applicants respectfully request the rejection be withdrawn.

35 U.S.C. §103(a) Claim 59

Claim 59 stands rejected as being unpatentable over *Miura* in view of *Dubin* and *Wang*, and further in view of *Dubin ('217)* (U.S. Patent Publication No. 2004/0108217). In response, the Applicants have amended claim 59 to more clearly recite certain aspects of the invention.

As discussed, the combination of *Miura*, *Dubin* and *Wang* does not teach or suggest directly electroplating a copper seed layer on a barrier layer and annealing the copper seed layer in an oxygen free environment disposed on the substrate, depositing a copper gap-fill layer and annealing the copper gap-fill layer disposed on the substrate, as recited by independent claim 59. Furthermore, the combination of *Miura*, *Dubin* and *Wang* does not teach or suggest another annealing process performed after a copper gap-fill layer, as recited by claim 59. *Dubin ('217)* teaches electroplating a copper layer for metal interconnection. However, there is not teaching or suggestion from *Dubin ('217)* that would suggest to one of ordinary skill in the art to modify *Miura*, *Dubin* and *Wang* in a manner that would yield directly electroplating a copper seed layer on a barrier layer and annealing the copper seed layer in an oxygen free environment disposed on the substrate, depositing a copper gap-fill layer and annealing the copper gap-fill layer disposed on the substrate, as recited by claim 59. As such, a *prima facie* case of obviousness has not been established as the references fail to teach each claimed elements.

Thus, the Applicants submit that independent claim 59, is patentable over *Miura* in view of *Dubin* and further in view of *Wang* and further in view of *Dubin ('217)*. Accordingly, the Applicants respectfully request the rejection be withdrawn.

CONCLUSION

Thus, for at least the reasons discussed above, the Applicants submit that all claims now pending are in condition for allowance. Accordingly, both reconsideration of this application and its swift passage to issuance are earnestly solicited.

If, however, the Examiner believes that any unresolved issues still exist, it is requested that the Examiner telephone Mr. Keith Taboada at (732) 530-9404 so that appropriate arrangements can be made for resolving such issues as expeditiously as possible.

Respectfully submitted,

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